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# Copper Bromide Laser Treatment of Facial Telangiectasia: Results of Patients Treated Over Five Years

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***Background and Objective:*** **Various yellow light lasers have been used over the past decade in an attempt to eradicate facial telangiectasia. Based on their power output, spot size, and pulsing characteristics, these lasers belong to one of two categories that exist at either end of a spectrum—high power, short pulse, and large spot size, or low power, long exposure, and small spot size. The copper bromide laser clearly belongs in the latter group, but with higher available power than most other lasers in this group, it exists further along the spectrum toward the region in which the laser parameters might be considered closer to theoretical ideals for treating certain cutaneous vascular pathologies. The objective of this study was to ascertain the role and efficacy of the copper bromide laser on treatment of a variety of facial telangiectasia.**

***Study Design/Materials and Methods:*** **A total of 570 patients with facial telangiectasia of different diameters and on different regions of the face were treated with the copper bromide laser one or more times and followed up over 5 years.**

***Results:*** **More than 75% clearance was achieved in 70% patients, 50–75% clearance in 17.4% patients, and <50% clearance in 12.6% patients. Poor results were correlated with anatomical location on the nasal alae and nasal tip and also with vessel size. Very small (<100 μm) and very large (>300 μm) vessels did not respond as well as vessels in the 100–300-μm diameter group. Very large vessels responded better to a combination of sclerotherapy and laser treatment. There were no reported long-term adverse effects.**

***Conclusion:*** **The copper bromide laser is a safe and effective modality for the treatment of the majority of facial telangiectasia. It is less suited to treating very small vessel lesions such as diffuse erythema, and conversely very large vessels as well as those of the nasal alae. These latter two groups respond better and more permanently to combined sclerotherapy and laser treatment. Lasers Surg. Med. 21:329–340, 1997.**



**Key words: exposure duration; photothermolysis; vessel diameter; yellow light**

## INTRODUCTION

Telangiectasia of the face are common cosmetic blemishes for which patients frequently seek medical therapies for their eradication. Women consider such vascular ectases troublesome because of the difficulty in disguishing them with makeup, but men also frequently seek treatment because of the erroneous but commonly held misconception that they are associated with excessive alcohol consumption.

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Telangiectasia of the face vary markedly from patient to patient in their size, anatomical location, colour (pink through purple), pattern (linear, arborizing, random), and aetiology. Known associations include acne rosacea, systemic, or topical corticosteroid use, connective tissue diseases, and others. However, the vast majority of telangiectasia are idiopathic in nature, although occurring more commonly on those with Fitzpatrick types I and II skin and history of considerable sun exposure especially during childhood. Undoubtedly, hereditary predisposition is a major factor.

Prior to the advent of lasers, the available treatments for these superficial skin blemishes were electrocautery in the form of needle diathermy, and microsclerotherapy. The disadvantages of diathermy include its low efficacy and high incidence of adverse sequelae such as localised skin atrophy and pigmentary changes. Sclerotherapy is limited to those vessels of adequate diameter to admit a #30 or #32 needle. In addition, some vessels seem resistant to sclerotherapy.

A variety of lasers have been used effectively to reduce or eradicate telangiectasia over the past 20 or so years [1–11]. However, a greater understanding of laser-tissue interactions and a recent wealth of clinical research, especially in relation to laser treatment of other superficial cutaneous lesions such as port-wine stains, has encouraged laser systems to be purpose-designed with parameters that selectively destroy only the target structure, sparing other skin components from nonspecific damage [12–15].

The concept of selective photothermolysis utilising a wavelength of light preferentially absorbed by haemoglobin over other skin pigments, a pulse width sufficiently short to limit thermal damage to the target vessel, and power output adequate to heat the vessel to ~7°C within that short exposure time has been used to design laser systems specifically for the treatment of port-wine stains. The prime example of this concept is the flashlamp-pumped pulsed dye laser (FPDL). Other yellow-light lasers, such as argon pumped-dye (APDL) and copper vapor (CVL) systems, are in common use for treating vascular lesions, with some advantages over lasers emitting wavelengths that are less preferentially absorbed by haemoglobin [16]. Nonetheless, power output of the laser, spot size, and exposure times are equally as important as wavelength in determining the effectiveness of the laser. Low power and long exposure times (hundreds of milliseconds) will result in nonspecific thermal damage regardless of wavelength [17].

The FPDL has been demonstrated to be the most effective modality with the least adverse effects for the treatment of paediatric port-wine stains [18–20]. The diameters of component vessels of such lesions are commonly in the range of 30–70 μm. It has been calculated that almost all of yellow (577 nm) laser light incident on a blood vessel is absorbed in the most superficial 32 μm [14]. It has also been calculated that if the exposure duration of that light on the vessel is less than or roughly equal to the thermal relaxation time of the vessel, the energy will be confined to the vessel and minimal thermal damage to surrounding tissue through conduction of heat will occur [21]. The picture becomes more complicated when vessel diameters exceed the maximum absorption depth of yellow light into haemoglobin. A vessel of a diameter greatly exceeding this absorption depth, e.g., 200 μm, will be thermally damaged through only an upper crescent [15,24, 30,31]. If a major proportion of the endothelial surface remains viable after laser irradiation, recanalisation is likely to occur. This may be an explanation for the observed reduced efficacy of the pulsed dye laser on the higher grades of PWS, i.e., those composed of significantly larger vessels [22]. A laser that can deliver yellow light for a period of time longer than the thermal relaxation time of the vessels (Table 1), but a time still short enough that thermal damage to nonvascular structures will be minimal, may offer considerable advantages for treating cutaneous lesions composed of larger vessels. In addition, a longer exposure may permit just enough heat diffusion to create a narrow perivascular "collar" of thermal damage for more permanent vessel sclerosis [16].

The copper bromide laser (CBL) has been used for 7 years in our clinic by four physicians to treat a wide variety of cutaneous lesions. For the purposes of this study, only the results of the last 5 years of treatment of face and neck telangiectasia have been analysed. Prior to this time, our pretreatment assessments and recording of treatment parameters were not adequately detailed for comparison with subsequent results.

## MATERIALS AND METHODS

The laser used was a Copper Bromide (Norseld CuB D-10, Adelaide, South Australia), emitting 578 nm (yellow) and 511 (green) light in

**TABLE 1. Thermal Relaxation Times***

| | Of vessels of various diameters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (μm) | 30 | 50 | 70 | 100 | 150 | 200 | 250 | 300 | 350 | 400 |
| $t^r$ (millisec.) | 0.4 | 1.0 | 2.0 | 4.2 | 9.4 | 16.7 | 26.0 | 37.5 | 51.0 | 66.7 |

*These thermal relaxation times have been calculated from the equation

$$t^r = \frac{d^2}{16\propto}$$

where $\propto$ is the thermal diffusivity of water

$$\propto = \frac{\text{Conductivity}}{\text{Specific heat} \times \text{Density (of water)}} = 1.5 \times 10^{-7}\ m^2\ sec^{-1}$$

where the conductivity of water at 37°C is 0.623 W $m^{-1}$ $K^{-1}$, specific heat is 4183 J $kg^{-1}$ $K^{-1}$, and the density of water 993 kg $m^3$. These constants are quoted from the *CRC Handbook of Chemistry of Physics*, 64th edition, which is taken from the National Standard Reference Data System Publications, National Bureau of Standards of the US Department of Commerce.

a train of 30 ns pulses at 16 kHz. Only the yellow wavelength was used in this study. The peak power per pulse was 4 kW. However, in this quasi-continuous mode the average output power measured at the fibre tip using a dual silicon diode power meter was 2 Watts. This light was then mechanically chopped into exposure durations of 7 millisec (minimum) up to 60 millisec. Variations of 1 millisec were possible, although changes in exposures were generally selected in 5 millisec increments.

The laser light was delivered via a 600 μm quartz fibre, with a naked polished fibre tip as the mode of delivery to the skin. This mode was used to avoid the small power losses that occur when a lensed system is used. The fibre tip was held at 0.5–1 mm from the skin surface, initially using a spacing device but more latterly relying on operator experience, as the spacer tended to interfere with localised skin blood flow. At 0.5 mm from the skin, the spot size was 0.75 mm diameter. At 1 mm from the skin surface, the spot size was 0.9 mm. Energy densities were calculated on the mean between these spot sizes, at 0.82 mm. Clearly, some variation in energy density from exposure to exposure was inevitable. The exposure repetition rate was variable up to 12 exposures per second. Most patients found the pain level of 3–4 exposures per second tolerable without the need for anaesthesia.

Over a period of 5 years, 838 patients presented to our clinic seeking treatment of essential facial or neck telangiectasia; 570 were subsequently assessed for the purposes of this study, 417 by clinical assessment and 153 by questionnaire self-assessment. Clinical assessments were generally made by the treating physician in a nonblinded fashion. Many of the patients had returned for other reasons over the 5 years of the study and were assessed at that time. The remainder were sent letters inviting either a visit to our clinic for the purposes of clinical assessment or reply by questionnaire. Of the patients who were sent letters, 237 did not respond at all. Thirty-one of these patients were lost to follow-up due to change of address.

Those with conditions known to predispose to ongoing formation of new telangiectasia were treated but excluded from this study. Such conditions were ongoing systems or topical corticosteriod use, collagen diseases, and acne rosacea diagnosed at or after laser treatment, although patients with a past history of this disease with no evidence of it during the 5 years of the study were included. It was our opinion that these patients were probably misdiagnosed in the first instance.

The female:male ratio was 467:103, age range 19–76 with a mean of 42 years. All patients were of Fitzpatrick skin types I to III, with most being fair-skinned Caucasians of European descent.

Recorded data included the predominant location(s) of vessels (Table 2), and the average vessel size as measured by a Peak 10 times magnifying loupe with a 100 μm scale. Patients were then further categorised as having predominantly small (up to 100 μm), medium (100–200 μm) large (200–300 μm) and very large (>300 μm).

For all telangiectasia, the 578 nm wavelength was chosen. In any treatment session all visible telangiectasia were laser irradiated. The method of treatment involved progressing the laser handpiece along individual vessels at a speed dictated by the exposure repetition rate, until the vessel was seen to disappear. This technique necessitated adjacent or minimally overlapping spots. Magnification was not employed. The minimum exposure duration that would achieve vessel disappearance without whitening the skin was chosen for each vessel or group of vessels. Actual

**TABLE 2. Results According to Location on Face**

| | Vessel clearance | | | | | |
|---|---|---|---|---|---|---|
| Lesion location | 0–25% | 26–50% | 51–75% | 76–90% | over 90% | Total |
| Cheek | 16 | 27 | 50 | 158 | 101 | 352 |
| Cheek/nasal alae | 1 | 4 | 24 | 70 | 23 | 122 |
| Chin | 1 | 1 | 3 | 3 | 1 | 9 |
| Nasal tip/alae | 2 | 11 | 7 | 4 | 3 | 27 |
| Nasal tip/alae and bridge | 0 | 5 | 12 | 15 | 7 | 39 |
| Nasal bridge | 0 | 3 | 1 | 10 | 3 | 17 |
| Neck | 1 | 0 | 2 | 1 | 0 | 4 |
| Total | 21 | 51 | 99 | 261 | 138 | 570 |

**TABLE 3. Results According to Number of Treatments**

| | Vessel clearance | | | | | |
|---|---|---|---|---|---|---|
| No. of treatments | 0–25% poor | 26–50% poor | 51–75% good | 76–90% excellent | >90% excellent | Total |
| 1 | 17 | 28 | 40 | 102 | 57 | 244 |
| 2 | 3 | 16 | 42 | 82 | 50 | 193 |
| 3 | 1 | 5 | 14 | 29 | 14 | 63 |
| 4 | 0 | 2 | 2 | 26 | 8 | 38 |
| 5 | 0 | 0 | 0 | 11 | 4 | 15 |
| >5 | 0 | 0 | 1 | 11 | 5 | 17 |
| Total | 21 | 51 | 99 | 261 | 138 | 570 |

blanching or whitening of the skin was not sought and if seen was used as an index to reduce the energy density by reducing the exposure duration. This was easily achieved using the laser's computer control.

The power output, exposure duration, and energy density were automatically recorded on the laser's computer during each treatment. For the purposes of the study, the predominant exposure time and energy density used in any one session was included on the patient's data record. If the patient underwent two or more treatment sessions, the average of these values was recorded in the data.

The duration of each treatment was recorded to the nearest 10 minutes, consistent with accounting methods of our clinic.

Patients returned for more treatment only as they felt the need to do so. The number of treatments per patient is recorded in Table 3.

Through the latter 2 years of the 5-year study period, a group of patients underwent a method of treatment that we termed combined laser/sclerotherapy (L/S). These were patients who exhibited telangiectasia in areas notorious for recurrence or resistance to either laser therapy or sclerotherapy alone. Typically, these vessels were located on the nasal alae or the sebaceous skin of the nasal tip and the chin. Additionally, vessels of large diameter (>300 μm) and those demonstrating high flow characteristics (rapid return when blanched by digital pressure and released) came into this category. L/S involved injecting the vessels with enough hypertonic saline (H.S. 30% combined with lignocaine 2% in a 2:1 ratio) to visualise vessel blanching for ~5 seconds, and then laser irradiating the same vessels within a few minutes after visible reduction of the vessel lumen diameter was seen to have occurred. In these instances, the end-point for laser treatment was not vessel disappearance, but immediate purplish colour change of the vessel and loss of "blanchability." When patients underwent L/S, this treatment was recorded on their data record. If both laser alone and L/S were performed during different treatment sessions the outcomes of each form of treatment were recorded.

Patients in the group who returned for clinical assessment were questioned regarding treatment sequelae such as blistering, crusting, swelling, pain, or bruising, although the accuracy of this data is questionable as many patients who returned after 3 or 4 years had elapsed could not recall details of posttreatment sequelae. Those who did not return were asked to complete a questionnaire that sought the patient's self-assessment of vessel clearance, from 0–25%, 26–50%,

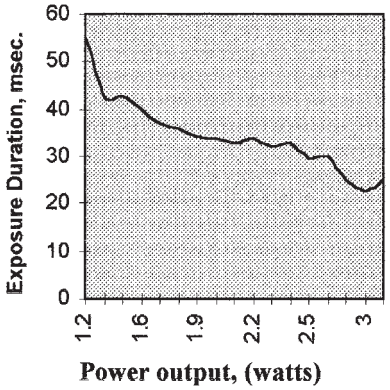


Fig. 1. Average exposure durations used for various power levels.

51–75%, 76–90% and >90%. They were also asked to list any adverse outcomes such as pigmentary changes, trophic skin changes, worsening of telangiectasia, or other complications not specified.

## RESULTS

Of the 570 patients assessed by one or other methods, 244 had undergone one treatment, 193 two treatments, 63 three treatments, 38 four treatments, 15 five treatments, and 17 more than five treatments. Several of the patients who underwent more than one treatment returned on a roughly annual basis for a short "touch-up" treatment of new or residual vessels. Twelve patients were in this category. The exact details of reasons for repeat treatments were not specifically recorded. Others refrained from further treatment because satisfaction was achieved despite <100% clearance, or because of financial restraints (this therapy in Australia is not rebatable by any government or private insurance scheme).

The treatment sessions ranged from 5 minutes to 60 minutes, the average treatment session being 16.7 minutes in duration. For patients undergoing more than one treatment, subsequent sessions were typically about half the duration of the initial session.

The output power of the laser varied from 1.1 Watts to 3.2 Watts over the 5 years, with an average treatment power of 2 Watts. The higher the available power from the laser the shorter the exposure necessary to achieve the desired clinical response (Fig. 1).

Of the patients who were questioned about treatment sequelae, most reported that the moderate erythema that was evident by the end of the treatment session subsided over 2–3 hours. There was no post-treatment pain, although a few patients reported a feeling of heat or flushing for the remainder of the day of treatment.

Analgesics, ice compresses, and topical lotions were not necessary, although sunscreen factor 15 was given routinely to all patients upon completion of each treatment. There were four reports of mild blistering of the skin, which subsided over 24 hours. Patients who had a 20-minute treatment or more, indicative that a moderate to large number of vessels were treated, usually experienced some swelling especially in the upper cheek/lower eyelid area. This rarely persisted longer than 48 hours, except where sclerotherapy had been performed in conjunction with the laser treatment. Thirteen patients reported light crusting along the tracks of large vessels treated. None of the patients treated felt the need for time off work or social isolation for any period after the treatment.

Table 3 depicts the overall recorded results of all patients treated with the copper bromide laser and followed up over 5 years, according to the number of treatments per patient. If 0–50% clearance is considered a poor result, 50–75% good, and >75% excellent [23], then 72 (12.6%) patients showed a poor result after an average of 1.51 treatments, 99 (17.4%) showed a good result after an average of 1.85 treatments, and 399 (70%) showed an excellent result after an average of 2.17 treatments.

Table 3 indicates results based on anatomical location of vessels on the face. The cheek, preauricular area, and forehead were individually assessed and found to have similar results, so were grouped together under the classification of "cheek." However, the nose, especially the nasal tip and alar sides, the chin, and the neck all behaved differently to each other.

From this it can be seen that 259/352 (73.6%) patients with predominantly cheek vessels showed an excellent result, and 50/352 (14.2%) a good result, with only 43/352 (12.2%) showing <50% clearance of vessels. In contrast, only 7/27 (25.9%) showed an excellent result when the vessels of the nasal alae and/or tip were treated, and 13/27 (48.1%) had unsatisfactory results. When the cheeks *and* the nasal sides were treated, the cheeks were generally viewed by the patient and the assessor as the most aesthetically significant area treated and the results reflected those of treatment of the cheeks rather than the nose, with 93/122 (76.2%) achieving an excellent result, 24/122 (19.7%) a good result, and only 5/122

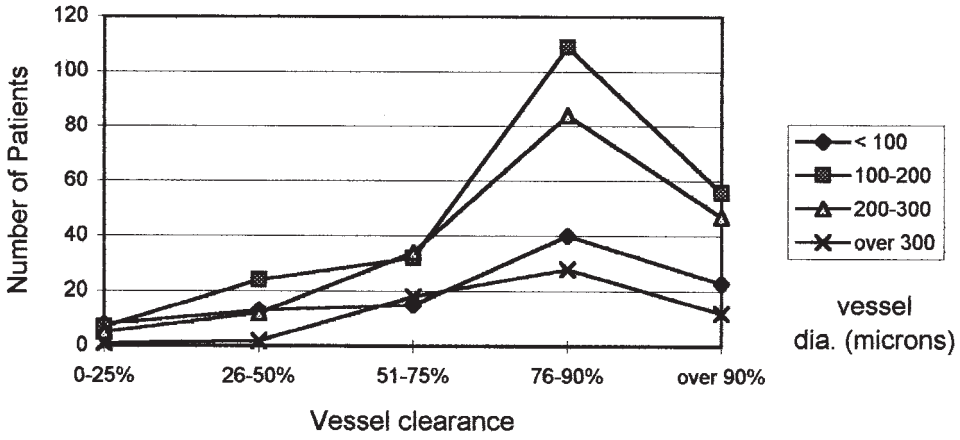


Fig. 2. Results according to vessel diameter.

(4.1%) a poor result. Patients who had vessels treated on either the neck alone or the chin alone were too few in number for meaningful analysis. When nasal telangiectasia involved the entire nose including the upper dorsum and sides, the results were considerably better than when vessels were located only on the more distal, sebaceous skin of the tip and alae.

The results of treatment were also correlated with other variables. Figure 2 shows vessel clearance according to vessel diameter; 63/99 (63.9%) had an excellent result when the predominant size of the vessels was <100 μm but 8/99 (21.2%) showed a poor result. In comparison, 165/228 (72.4%) of the medium size vessel group and 111/182 (71.9%) of the large vessel group had an excellent outcome with poor results in 7/228 (13.6%) and 5/182 (9.3%), respectively. When very large vessels (>300 μm) were treated, the excellent results dropped back to 40/61 (65.5%), although the number of poor results in this group was only 1/61 (4.9%). An example of medium-size vessels on the cheeks before and after one treatment is shown in Figure 3a, b.

The data were further analysed to ascertain whether there was a significant difference in vessel sizes for different locations on the head and neck. This revealed that there were vessels of all sizes represented in each anatomical location in roughly similar percentages, except on the neck and chin where there were insufficient numbers for data analysis.

Vessel size was then correlated with exposure duration and energy density. As can be seen from Table 4, both exposure time necessary to achieve the desired clinical end point, and the energy density (as a function of exposure duration) increased as the diameter of the targeted vessels increased.

In the self-assessment group, 28 patients who reported good or excellent results for the vessels on their cheeks also commented that the vessels on the nasal alae had responded to lesser degree. Another 43 patients who were assessed by the investigators as having good or excellent results with respect to the site(s) of their most prominent vessels were noted incidentally to have recurrent or persistent nasal alar vessels when seen >2 months after treatment. Results obtained from the group assessed by the investigators compared to the group self-assessed by questionnaire are depicted in Figure 4.

The patient data records included comments on individual factors or observations that were difficult to statistically correlate with results, but were felt to be worthy of note. Fifty-seven patients underwent L/S treatments, mainly during the latter 2 years of the study period. Twelve of these patients had an L/S treatment after a treatment with the laser alone had achieved <50% clearance. All of these patients showed greater clearance of vessels with L/S than with laser alone. Of the other 45 patients who were treated with L/S at their initial visit, 36 (80%) had good or excellent results despite these vessels predominantly being located in the sebaceous areas of the face or being in the "very large" category (Fig. 5a, b).

There were no reports of scarring or hyperpigmentation in either the clinically assessed or the self-assessed groups. This does not mean that pigmentary changes never occurred; in patients who described crusting along the lines of vessels after treatment, some pigmentary changes would be anticipated. However, by the time of assessment, which was routinely >2 months after treat-


Fig. 3. **(a)** A 56-year-old woman with type 2 skin and medium telangiectasia before treatment. **(b)** Seven weeks after one 30-minute treatment with the copper bromide laser, using 2.4 Watts of 578 nm yellow light, average exposure duration 30 millisec, energy 13.6 Joules/cm$^2$.

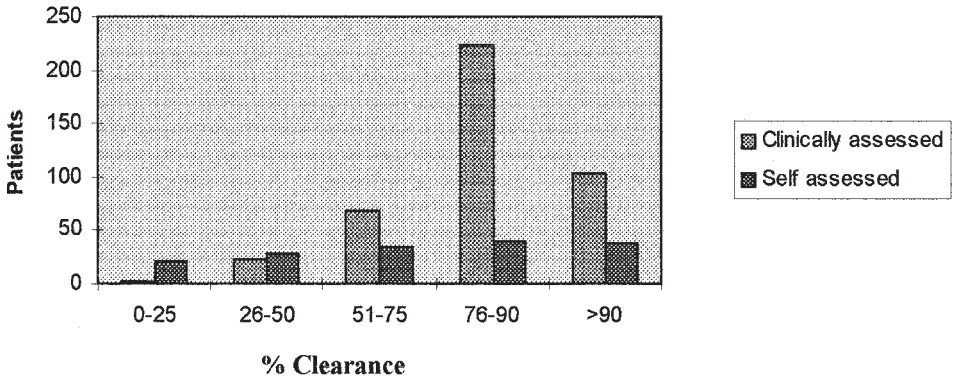


Fig. 4. Comparison of 417 clinically assessed patients with 153 questionnaire self-assessed patients.

ment and as long as 5 years, no such adverse effects were evident. There were three cases of hypopigmentation along the lines of very large vessels treated, all on the nose (see Fig. 5b).

## DISCUSSION

Lasers currently available whose parameters approximate at least some of the theoretical principles for selective photothermolysis of vascular lesions of the skin all exhibit certain limitations. The flashlamp-pumped, pulsed-dye lasers have been designed to emit at wavelengths from 577–585 nm and at 450 microsec pulse durations, although more recently a laser emitting a 1.5 millisec pulse has been in trial [25]. However, the limitation of flashlamp-pumped laser technology is the lack of flexibility with respect to the pulse duration. The energy densities of these machines are varied by alterations in the output power. As theoretical modelling and laboratory studies suggest that vessels of different diameters require pulse durations proportional to their thermal relaxation times, a laser that can emit variable pulse widths in the millisec range is desirable for treating lesions in which the component vessels may exhibit wide variations in diameters [24,26,30]. Hohenleutner et al. [27] have shown that when vessels of port-wine stains are >150 μm in diameter, the coagulation with the FPDL is incomplete [27]. This is also likely to be the case with telangiectasia.

At the opposite end of the yellow-light laser spectrum are the copper vapor and argon-pumped dye lasers. The common limitation of most of the commercially available models of these types of machines is their low output power, variably quoted from a few hundred milliwatts [10] to 1.3 or 1.4 Watts [16,24]. To achieve adequate energies for photocoagulation with low power, the exposure time must be necessarily long, usually in the order of 50 millisec or more, or the spot size must be very small. Both factors further compromise the ability of the laser to achieve selective damage to the target vessel. Histologic studies have demonstrated that very long exposure times result in nonspecific thermal injury to dermis and epidermis [17,21], although it has been shown that an exposure duration of up to 74 millisec was compatible with selective vessel damage [17]. Alternatively, if the power density is maintained by reducing the spot size to fractions of a millimeter, the effective energy incident on vessels is reduced by light scattering in tissue. In this situation for the same energy density to be incident on the vessel, the energy density incident on the epidermal surface must be proportionately higher for small spot sizes than for larger spot sizes. Conversely, using a spot size of 3–5 mm for the treatment of telangiectasia might be considered excessive, with a significant area of nonlesional skin being subjected to laser irradiation. For telangiectasia, it would seem rational to use a spot size that is large enough to avoid both the problems of attenuation due to scatter and the practical difficulties of microspot vessel tracing, but small enough to avoid irradiation of nonlesional skin.

A yellow-light laser that can emit sufficient power to allow variable exposures from 500 microsec to 30 or 40 millisec, with a minimum spot size of ~1 mm for individual vessel irradiation and a maximum of 5 or 7 mm for treating confluent vascular pathologies such as port-wine stains is not yet commercially available as an office machine.

The CBL exhibits parameters that more closely approximate those considered desirable for treating most telangiectasia. An average out-


Fig. 5. **(a)** Very large telangiectasia on the nose of a 70-year-old man. **(b)** The result 6 months after one 20-minute treatment of combined laser/sclerotherapy, using sclerosant 30% hypertonic saline and 2% lignocaine, and laser parameters of 2.3 Watts, 40 millisec exposure duration, energy density 17.4 Joules/cm$^2$. Note mild hypopigmentation along the track of the largest vessels treated.

**TABLE 4. Average Durations and Energy Densities Employed for Vessels of Different Diameters.**

| Vessel size (μm) | Average exposure duration (msec) | Average energy density (j/cm$^2$) |
|---|---|---|
| <100 | 28.4 | 10.3 |
| 100–200 | 32.8 | 12.3 |
| 200–300 | 37.4 | 14.2 |
| >300 | 39.4 | 15.1 |

put power of 2 Watts allows adequate energy density within exposure durations in the range of 25–40 millisec and a spot size of ~0.8 mm, and the usual repetition rate of three to four exposures per second (exposure intervals of 250–300 millisec) allows thermal relaxation between successive laser impacts. This study confirms that with these parameters the CBL can photocoagulate a wide range of vessel sizes with high degree of efficacy and very low incidence of adverse sequelae. The data in Table 4 confirms that longer exposures and resultant higher energy densities have been used as vessel diameters increased. As predicted, the CBL has proven less effective for the treatment of vessels <100 μm in diameter, whose thermal relaxation times are shorter than 4.2 msec. (Table 1).

The fact that this laser is most effective for treating vessels in the size range 100–300 μm is consistent with current theory, that vessels up to ~100 μm need exposures of ~1–5 millisec for optimal selective damage [24], and that larger vessels, because of the nonuniform absorption of light through the vessel [21,30], may benefit from exposures slightly longer that their thermal relaxation times (possibly up to twice $t^r$ [15]).

The reduced effectiveness of the laser when the targeted vessel was >300 μm is also explicable. A single exposure of 578 nm light on a large column of blood will result in coagulation and necrosis of the superficial aspect of the vessel. The deep endothelium will then be protected from further laser irradiation, as the overlying "roof" of denatured protein and coagulum will become opaque, thus reflecting, scattering, and absorbing but not transmitting light [27,31]. The entire vessel will be only thermally damaged if sufficient energy is absorbed for heat to conduct downward through the vessel, in which case an equal or greater amount of heat will be diffused to overlying and surrounding tissues concurrently. In this instance, perivascular collagen and epidermal damage are likely.

On the basis of this theoretical and clinical research by others and with our own disappointing long-term results when treating very large vessels with either our CBL and our FPDL, we utilised a method of inducing a temporary reduction in the diameter of the target vessels with hypertonic saline sclerotherapy. Immediately upon injection of the saline, the vessel is seen to narrow. Whether this is a result of vessel spasm or endothelial oedema is uncertain, although we favour the former because of the speed with which this process occurs. Laser irradiation with the CBL within 2–5 minutes of injection resulted in visible purpuric colour change within the vessel and loss of blanchability by digital pressure. When this clinical end-point was seen, the usual outcome was complete resolution of that vessel. We have not been able to achieve this result with either sclerotherapy or laser treatment alone, although we refrain from using detergent and other strong sclerosants on the face on the premise that much of the facial venous drainage may be via ophthalmic vessels or may enter the cavernous sinus. The L/S technique using hypertonic saline appears to be both effective and safe.

The fact that the clinical end-point used in laser treatments was disappearance of the vessel without residual epidermal whitening correlates well with the low reported incidence of posttreatment side effects. Although there were no biopsies taken for histologic evaluation in this clinical study, the avoidance of the blanching effect that has been reported by others using CVL [28] and APDL [29], the infrequency of reports of blistering or crusting and the rarity of late pigmentary changes is suggestive of relative selectivity of vascular damage over non-specific epidermal and papillary dermal injury [17].

It should be noted that the actual incidence of posttreatment side effects is likely to be understated. Not infrequently, patients who returned for assessment some years after their initial treatments, who, during past visits had reported some posttreatment symptoms, had no memory of these events once considerable time had elapsed.

A similar pattern of behaviour seemed to apply to patients who, when sent a letter inviting a choice of either clinical or questionnaire assessment, refrained from returning for follow-up. This group showed a lower level of satisfaction with the treatment than those who elected to return (Fig. 4). In addition, the investigators made the observation that many clinically assessed patients who expressed doubts about the efficacy of their treatment when it had been performed more than a year previously often revised their opinion

of their own outcome when showed their pretreatment photographs. It is our impression that over time many people forget the details of the extent and severity of their original problem, just as they also forget details of short-term posttreatment sequelae. We also suspect that patients who are happy with their results are more likely to return for follow-up when invited. Less satisfied patients may have preferred to avoid a situation where they perceived potential conflict, especially if they had felt positive toward the treating physician but disappointed with the outcome. We therefore acknowledge that if all 838 patients treated over the 5 years of the study had been followed up, our data may have shown a slightly higher percentage of poor or mediocre results.

Of the 20 patients who self-assessed as <25% clearance, 11 either had vessels located on the nasal alae or tip, or else had very small vessels (<100 μm), both of which are factors that have been shown in this study to correlate with poorer results (Table 2 and Fig. 2). The reduced efficacy of this laser on very small vessels is not surprising in view of the laser's parameters and current laser-vessel interaction theory. However, vessel size does not explain the poor results of treatment of nasal alar vessels. The high recurrence rate in this location may be more related to the relative normalcy regarding the anatomic existence of these veins, or perhaps the increased sebaceous content of this skin. They remain, nonetheless, an issue of great concern to many patients, worthy at least of exploration of more effective methods for their eradication.

Although not specifically analysed in our data, there is no doubt that good results are significantly operator dependent with this laser. Our anecdotal observations were that each of the four treating physicians noted improved results after they had been using the laser for >3 months, by which time they had had the opportunity to review some of their patients during follow-up visits and subsequently modify their treatment methods to achieve greater efficacy. The most common observations during this learning phase were evidence of undertreatment with many residual vessels evident at follow-up, but at the same time longer exposures and higher energy densities were recorded on the laser's computer database. With experience, the operating physicians became more adept at keeping the fibre tip at a constant distance from the skin. This technique kept the spot size small, the power density high, and the exposure time for the desired clinical response short. The other problem regularly encountered with the naked fibre tip mode of light delivery was the ease of fouling the fibre end by touching fine hairs or accidental contact with the skin surface, thus immediately reducing the power available to the skin. The inexperienced operator would see the resultant reduced clinical response as an indication to increase the exposure time, when the correct management of this problem was to clean, or to cleave, the fibre tip.

## SUMMARY

Facial telangiectasia remain an undesirable cosmetic problem for many adults, with the incidence possibly increasing in Australia secondary to a generation of sun worship along with reported increases in environmental ultraviolet levels. However, the problem is rarely of sufficient concern to patients to prompt them to take time off work or tolerate social isolation for any period following treatment. Therefore, a therapeutic modality that offers high efficacy with minimal posttreatment reaction or sequelae must be considered desirable. The copper bromide laser, utilising its yellow wavelength, can satisfy these criteria for the majority of facial telangiectasia.

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